Electric Railway Traction

The Possibilities of Electrification in Different Fields

A TYPICAL instance of the present trend of railway thought is to be found in the schemes now being put forward for the electrification of a number of lines belonging to the Polish State Railways. Like proposals in many other countries, they have been thought about, talked about, and written about for a decade, and although for a time they were shelved in view of the unsatisfactory financial position, it is an aggravation of that position which has been largely responsible for the work now having been put in hand. A further point of similarity with certain other schemes, such as the forthcoming electrification of a section of the Central Railway of Brazil, and the recent conversion of the Budapest-Komarom main line of the Hungarian State Railways, is that it has been the enterprise of British firms which has led to the final decision being made, not only by the partial financing of the projects, but also by the excellence of the electrical equipment supplied from this country. It is generally supposed among those who have not considered the subject in great detail, that the saving in the cost of locomotive coal is one of the principal advantages of electrification, and although in many cases this is so, it by no means follows that little or no saving in the fuel bill rules out the possibility of electrification proving a paying proposition.

As was emphasised in the December 15 issue of this Supplement, the proportions of the different savings to be effected by a conversion to electric traction may vary from district to district, and the estimates made by the Polish State Railways for the conversion of certain of their lines provide an excellent example. In Table III of the article on Electrification in Poland, which is published in another part of this issue, are given the results of careful calculations made for three different main-line sections of the Polish railway system, and it will be seen therefrom that on the division where electrification will show up to best advantage, the saving in the cost of electric power over the steam locomotive fuel bill is the smallest, the reduction amounting to scarcely 10 per cent. The greatest economies are to be found under the headings of wages, maintenance, and repairs, the reduction in the first-named category being largely due to one-man operation, which is permissible where a dead-man handle device is fitted, and to the reduction in the ground staff of both the locomotive and operating departments. On the Warsaw-Sosnowiece and Warsaw-Dabrowa divisions a reduction of over 70 per cent. is anticipated in the locomotive repairs, and maintenance bill, and this is by no means an excessive allowance if the steam locomotive boilers are costly to maintain by reason of bad water or fuel. A dozen years ago, when costs were higher than they are to-day, Sir Vincent Raven, the Chief Mechanical Engineer of the North Eastern Railway, stated that the cost of repairs, inspection, preparation, and cleaning for the 1,500-volt d.c. electric mineral locomotives on the Shildon-Newport line was 1·5d. per engine-mile, of which repairs amounted to a little more than 1·0d. and the shed charges to a little less than 0·5d. The figures for the eight-coupled steam engines engaged on similar traffic was 11·5d. per engine-mile, of which repairs accounted for about 8·0d. and shed charges for about 3·5d. These figures were obtained from units working in a good water district, and results from a number of other countries show a reduction of over 50 per cent. Another advantage obtained from electrification, although one which it is difficult to assess in actual figures, is the greatly reduced maintenance cost of bridges, stations, tunnels, and lineside structures, due to the smokeless operation of electric power vehicles. Furthermore, the risk of property adjacent to the line catching fire by the emission of sparks is eliminated.

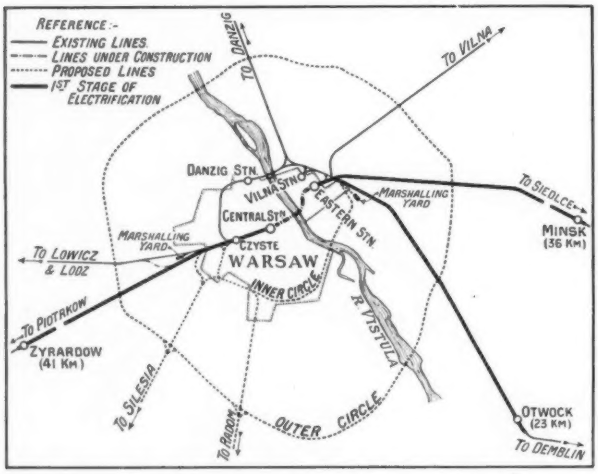
Under the conditions obtaining in Poland at the time the estimates were made, it was found that a return of six to seven per cent. on the capital invested could be anticipated only on lines where the traffic density equalled or exceeded 5,000,000 trailing tonnes per km., a figure which is a good deal higher than would be required in the majority of Western European countries. Nevertheless, there were in 1928-29 some 1,800 km. of line in Poland which carried a traffic exceeding 7,000,000 trailing tonnes per km., and although traffic on most of these lines has fallen off in the last three years, it has increased on others, and fuel and labour charges are more favourable. Apart from the 475 route miles, the electrification of which has been definitely decided upon, and the three sections included in the above-mentioned table, the conversion of several other heavy-traffic divisions has been studied, including the 340-mile line from the Silesian coalfield to the port of Gdynia, via Herby, Gniezno, Bydgoszcz, Tczen, and Danzig, which in the peak period of 1928-29 had a traffic of approximately 22,000,000 trailing tonnes per km. But in view of the construction by a private company, under a concession from the Polish Government, of a direct line which passes up the Polish corridor, and does not touch Danzig, it is doubtful whether this line will ever be worked electrically. One of the fields in which electric traction has operated most successfully over many years is on mountain lines, and despite a traffic amounting to only 1,400,000 trailing tonnes per km., the Polish Government have decided to electrify the heavily-graded line between Krakow and Zakopane, near the Czechoslovakian frontier. An excellent example of the economies for which electric traction may be responsible on steeply-graded lines whose traffic is approaching the maximum capacity of steam locomotives is to be found on the Paulista Railway, in Brazil, a description of the electrification of which is given on pages 76-78 of this Supplement. The main line is single track for 150 miles out of 177, and conversion to electric working not only made doubling of the line unnecessary, but brought down the cost of operation by 67 per cent. Such results make it obvious that if electric energy can be obtained cheaply, and money borrowed at a reasonable rate of interest, there are many lines where electrification would not only reduce the operating cost by a substantial amount, but would bring increased profits by virtue of the extra traffic which invariably follows in its wake.

ELECTRIFICATION IN POLAND

Extensive projects for the conversion of main and suburban lines

SINCE the formation of Poland as a separate State in 1919, close attention has been given to the question of electrifying certain lines with dense traffic or heavy grades, and as 93 per cent. of the total railway mileage in the country is owned by the State, it has been possible to consider the electrification proposals very broadly.

As early as 1922 a government commission reported in favour of electrifying certain lines on which it was anticipated that comparatively large savings in operating costs would accrue. The acute financial position prevented any immediate steps being taken, but at a later date further estimates and comparisons were made for the lines converging on Warsaw, on systems of electrification which would be suitable for eventual extension to main lines. The four systems considered were 1,500 and 3,000 volts d.c., 15,000 volts $16\frac{2}{3}$ and 50 cycles single-phase, and tenders were received from 17 firms for the conversion of



Map of railways to be electrified round Warsaw

460 miles of line, of different traffic densities, alternative estimates being submitted for the four types of electrification.

At the beginning of 1932 the Government decided to authorise the electrification of the Warsaw suburban lines, and, as at the same time they proposed to put in hand at an early date schemes for the electrification of certain main lines, 3,000-volt d.c. was chosen in order to avoid any further complication. Almost simultaneously, a concession was given to a private company for the construction of a new 100-mile line from Warsaw to Ostrowiece via Radom, which is to be worked electrically by ten locomotives, 15 motor-coaches, and 40 trailers. Ten sub-stations, each of 1,500 kW. capacity, will feed the line. The calculations made for various sections of the Polish State Railways by the commission of 1922 were found to require a good deal of modification, as the traffic had developed on other lines than those considered ten years before.

The problem of the suburban lines being most pressing, detailed plans were drawn up, and in July last a contract valued at £1,980,000 was placed by the Polish Government with the Metropolitan-Vickers and English Electric Companies for the completion and electrification of the main Warsaw junction railway. This scheme provides for a new line across the city, partly underground, to connect the Central and Eastern stations, so that trains from the west can pass straight across to the eastern side of the city, and *vice versa,* instead of having to reverse and pass through the Danzig station. Twenty trains an hour are estimated at the commencement of operation,

TABLE I.—RELATIVE COSTS OF INSTALLING DIFFERENT SYSTEMS

Stage of Programme (see Table II)	Direct Current		Single-phase Current 15,000 V., $16\frac{2}{3}$ Cycles	
	3,000 V.	1,500 V.	Produced Directly	Transformed
I	100·0	105·0	95·2	106·6
II	100·0	112·5	86·8	97·8
III	100·0	115·5	98·0	107·0

TABLE II.—ELECTRIFICATION PROPOSALS OF THE POLISH STATE RAILWAYS

Line	Route Kilometrage		No. of Trains a Day		Maximum No. of Trains an Hour	
	Total Length	Sub-urban Lines	Long Dist-ance	Sub-urban	Long Dist-ance	Sub-urban
STAGE I						
Warsaw City ..	7·5	7·5	122	133	9	11
Piotrkow ..	—	41·0*	—	48	—	4
Demblin ..	—	22·8*	—	40	—	4
Bialystok ..	—	35·8	—	22	—	2
Total ..		107·1				
STAGE II						
Warsaw City	7·5	7·5	122	133	9	11
Piotrkow ..	140·9	62·8*	29	48	3	4
Demblin ..	98·5	43·9*	21	40	3	4
Bialystok ..	172·3	53·8	22	22	4	
Lowicz	77·4	77·4	18	19	4	
Siedlce	126·7	84·6	16	22	5	
Mlawa	140·9	56·4	16	23	3	
Total ..	764·2					
STAGE III						
Warsaw City ..	7·5	7·5*	273	269	21	19
Piotrkow ..	140·9	62·8*	41	90	4	12
Demblin ..	98·5	49·3*	28	59	3	12
Bialystok ..	172·3	53·8*	44	58	4	6
Lowicz	77·4	77·4	36	24	4	6
Siedlce	126·7	84·6	32	42	7	4
Mlawa	140·9	56·4	34	42	6	
Radom ..	—	—	24	21	5	
Silesia	—	—	34	23	4	
Total ..	764·2					

* Quadruple track ; all other lines double track.

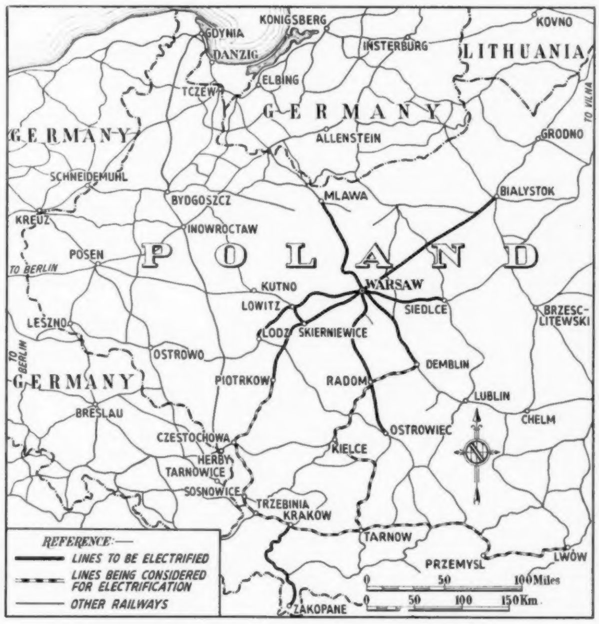
and the main line trains will be electrically-hauled between the Eastern and Central stations. This line will also do much to relieve the congestion now existing in the Polish capital.

On the completion of the city line, the conversion of the suburban sections of three main lines is to be undertaken, to Zyrardow 25·5 miles, on the Piotrkow and Breslau line; to Otwock, 14·25 miles, on the Demblin line; and to Minsk, 22·5 miles, on the Siedlce and Moscow line. Multiple-unit trains, operating from 3,000 volts d.c., will be run over these sections, which are scheduled for completion in 1935.

Included in the contract already placed with the Metropolitan-Vickers and English Electric Companies for the electrical equipment of these lines are six substations, with a total capacity of 29,500 kW., including the rectifiers, switchgear, transformers, auxiliaries, and equipment. Five 2,500 kW., seven 2,000 kW., and two 1,500 kW. rectifiers will be installed in these substations. Six heavy double-bogie locomotives with a horse-power of no less than 2,200 are to be supplied, together with the electrical equipment for 80 motor coaches of 800 h.p., and 250 trailers. The contract also covers the supply of the overhead contact line equipment for 134 track miles, including sidings, and six track-sectionalising cabins with high-speed circuit breakers. It is estimated that about one-half of the value of the whole £2,000,000 order will be spent in purchasing English materials.

Subsequent works are to include the construction of the southern half of the inner circle railway, and a construction of a new outer circle line, with marshalling yards at suitable junctions, which will be at a radius of approximately six miles from the Central station. It is intended eventually to extend the electrification to all the main lines converging on Warsaw, as far as the first big locomotive depot in each case. The second of the accompanying maps, which is drawn up from a paper read by M. Roman Podoski before the International Electrical Congress, shows the contemplated extensions out of Warsaw, and the attached tables, taken from the same source, show the electrification programme, in the three stages planned by the Polish engineers, which it is intended shall be spread over a period of 20 years.

Various projects for the electrification of lines in Silesia and elsewhere have been mooted, and representatives of the Metropolitan-Vickers and English Electric Companies are now in Poland investigating the Polish Government's £1,350,000 scheme for the conversion of the line from Krakow to Zakopane. The heavy grades on this section have been responsible for the proposals to electrify, for



Map of lines to be electrified in Poland

the traffic amounts to only 1,400,000 trailing tons per km. per annum. Other lines, additional to those included in Tables II and III, on which the cost of operating heavy traffic might be reduced by electrification, are: (*a*) Herby-Kepno-Gniezno Bydogoszcz-Tczew-Danzig-Gdynia, 545 km., 22,000,000 trailing tonnes per km. per annum; (*b*) Skierniewice-Lowicz-Kutno, 76 km., 13,000,000 trailing tonnes per km. per annum; (*c*) Zebrzydowice-Dziedzice-Oswiecim-Trzebinia, 76 km., 12,000,000 trailing tonnes per km., per annum.

TABLE III.—COMPARATIVE COSTS* OF STEAM AND ELECTRIC TRACTION

Line	Warsaw-Piotrkow-Sosnowiec (310 km.)		Warsaw-Demblin-Dabrowa (407 km.)		Lwow-Krakow (333 km.)	
Type of Traction	Steam	Electric	Steam	Electric	Steam	Electric
Annual trailing tonnes per km. of line (millions)	27·6	27·6	7·4	7·4	12·9	12·9
Wages, Operating Department	6,001,727	3,520,000	3,171,100	1,595,000	4,643,100	1,916,800
„ Locomotive Department	6,892,000	2,100,000	3,549,800	1,045,000	4,463,000	1,194,600
Fuel and lubrication of steam locos.; energy for electric tractors	10,332,833	11,491,130	5,362,700	5,004,000	7,770,930	6,000,000
Lubrication of electric stock	—	383,800	—	175,800	—	199,000
Repair and maintenance of locomotives and tractors	11,645,000	2,950,000	6,228,000	1,520,000	5,150,000	1,673,000
Renewal Fund for tractors and sub-stations	—	2,076,600	—	1,364,000	—	1,417,000
Renewal Fund for overhead lines and system	—	1,276,000	—	1,716,000	—	1,420,000
Maintenance of sub-stations and contact lines	—	542,000	—	693,000	—	665,500
Annual operating expenses	34,871,560	24,339,530	18,311,600	13,112,800	22,027,030	14,485,900
Saving by electric traction	—	10,532,030	—	5,198,800	—	7,541,130
Estimated cost of electrification†	—	112,720,000	—	95,095,000	—	89,300,000
Value of present steam locomotives	60,000,000	—	—	35,800,000	—	43,600,000

* In zlotys (43·38 zlotys to the £ at par; 29 to the £ at present rate of exchange).
† Neglecting capital charges and value of steam locomotives replaced.

CONTROL GEAR FOR MULTIPLE-UNIT SUBURBAN TRAINS

The lay-out of the equipment in suburban stock

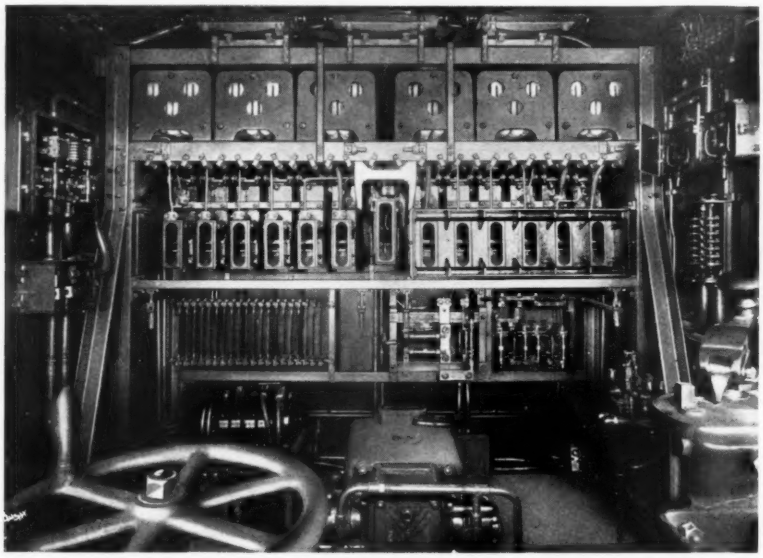


Fig. 1—Compartment-mounted electrical equipment in enlarged driver's cab

THE accommodation and lay-out of electrical control equipment on suburban electric railway motor coaches is a problem which has in the past been the subject of controversy. Although frequently influenced by local circumstances each requiring close study, certain general conditions present themselves for consideration.

As a rule the electrical control equipment of motor coaches for suburban service is suspended in dust-tight weather-proof cases beneath the underframes; but there are many railway engineers who prefer to have the electric equipment mounted in a special compartment in the coach itself. Underframe suspension is the method favoured by the railway traffic departments for the obvious reason that when equipment is mounted inside the coaches a certain amount of passenger or freight space is lost. When, however, reliability in operation and the costs of inspection and maintenance are taken into account, it does not necessarily follow that underframe mounting of electric equipment is the more economical method. This is particularly so where extreme climatic conditions exist.

There is no doubt that the preference shown by railway engineers for underframe-mounted equipment has led to greatly improved designs on which the costs of maintenance are exceedingly low. This development has taken place in both low voltage (600 volts) and high voltage (1,500-3,000 volts) installations, and a perfectly sound underframe-mounted equipment can be constructed for standard coaches operating under reasonable climatic conditions.

Equipment in Special Compartments

Compartment-mounted equipment may be arranged in an enlarged driver's cab, as shown in Fig. 1, or in a separate compartment adjacent to the driver's cab, as shown in Fig. 2. The combined equipment compartment and driver's cab is used only in a few 600-volt installations. It is usually preferable to mount the main control equipment in a self-contained room completely shut off from the driver's cab but to which access may be gained through a communication door. For 1,500 and 3,000-volt installations this door is mechanically interlocked in such a way that it cannot be opened unless the equipment in the compartment has been completely isolated from the line and earthed to the running rail.

In laying out an equipment compartment consideration has to be given, in the case of vestibule and corridor stock, to the desirability, and sometimes the necessity, of maintaining a through gangway from the driver's cab to the passenger compartments. In the case of stock operating on the tube sections of the London Passenger Transport Board's system it is necessary that a central gangway be maintained throughout the train so that in event of a serious mishap in a tunnel the passengers may find easy exit into the tunnel from both ends of the train. This is accomplished by dividing the equipment compartment into two sections separated by a central gangway, as shown in Fig. 2.

In cases where a central gangway is not a necessity, then a single compartment with a side gangway may be used, this arrangement usually giving a rather greater economy in space as well as simplifying the electrical connections between the various pieces of apparatus. A further advantage is that if mechanical interlocking of the compartment door has to be provided the single compartment lends itself to the simplest arrangement.

When the control apparatus and the main starting resistances are mounted together in a common compartment the problem of adequately ventilating the compartment is of great importance, as provision has to be made for dissipating the heat given off by the main starting resistances. If this is not done the excessive heat may have a detrimental effect on insulation and on the rubber covering of cables. It is, therefore, usual to provide ventilators in the roof, and either louvres in the side

walls or holes in the floor of the compartment, so that an upward stream of fresh air is created of sufficient amount to carry through the heat given off by the resistances.

Unfortunately this arrangement presents difficulties, in that the stream of fresh air passing upwards carries with it much track dust, finely-divided particles of brake-shoe dust, and moisture, and these become deposited in the electrical control gear, thus making removal for periodic cleaning necessary if an insulation breakdown is to be avoided. One method of overcoming this difficulty is to arrange the main resistances in a separate compartment by themselves, which alone is ventilated, thus maintaining the main switchgear compartment at a low temperature and ensuring that the apparatus shall remain clean. Designs have been worked out for this arrangement, but there is so far no knowledge of its having been adopted on motor coaches, although a similar arrangement is in use on locomotives. Such an arrangement is likely to take up a little more space than the conventional method on account of the air ducts that must be provided. Where conditions permit, probably the best solution is to mount the main resistances on the underframe, retaining all switchgear in a special small compartment. This arrangement has been adopted on some of the Met-Vick coaches on the Moscow suburban railways with complete success, no trouble having resulted in placing the resistance beneath the underframe, in spite of the Arctic conditions prevalent in Central Russia during the winter months. It may be mentioned that these equipments operate at 1,500 volts d.c., and that the resistance frames are suspended from the underframe on large porcelain insulators.

Considerable thought and skill are required in arranging the lay-out of the electrical control gear in an equipment compartment in order to obtain the following advantages:—

1.—Economy of space.
2.—Accessibility to all parts of the equipment that require periodic attention and maintenance.
3.—Simplicity of electrical connections between the various apparatus.
4.—Location of the main resistances relative to the switchgear and cabling, so that a minimum of heat is imparted to the latter.
5.—Adequate electrical clearances consistent with the working voltages.

The layout of the gear is, of course, largely influenced by the system of operation adopted and depends upon whether the equipment has been designed for electro-magnetic, electro-pneumatic or cam-shaft operation. Moreover, the gear may either be mounted on a framework which is built into the coach, or it may be built on to a removable framework with all connections completed before mounting in the compartment as a complete self-contained unit.

Easy Withdrawal

A well-known example of the latter method is that due to Lieut.-Colonel Cortez Leigh, Electrical Engineer of the L.M.S.R., in which the framework is mounted on rollers and is easily removable through a special door on the side of the coach. In this case the external connections between the frame-mounted gear and the coach control cabling are made by means of plugs and sockets so that the work of replacing a faulty equipment with a new one is of the simplest and entails merely the disconnection of the power cabling, the control gear being withdrawn *en bloc* as shown in Fig. 5. This system was fully described in the issue of this Supplement for October 27.

When a satisfactory arrangement has been obtained for the layout of the gear, bearing the foregoing points in mind, much still depends upon the adequate rigidity of the supporting framework and the proper erection of the cabling and interconnections, so that the whole may produce a pleasing and workmanlike appearance. It is the general practice to protect all power cabling by drawing it into solid-drawn heavy-gauge steel conduit, the conduit end terminating in a bell-mouth fitting and rubber bush,

Fig. 2—Electrical equipment in separate compartment

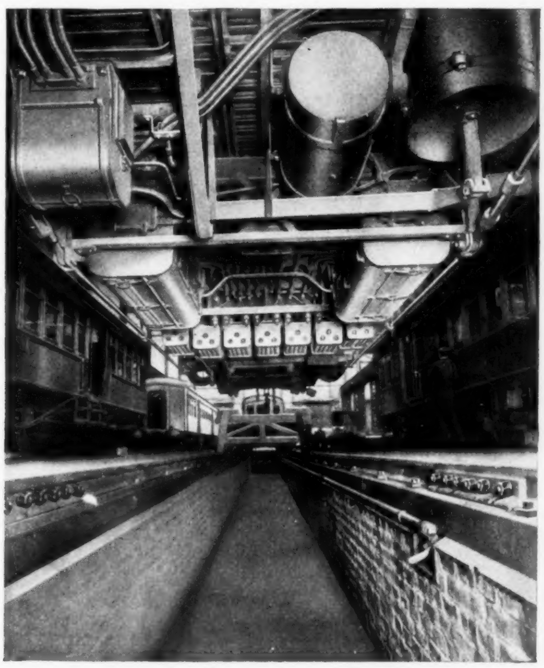


Fig. 3—Equipment suspended below underframe

just short of the cable terminal, to allow adequate electrical creepage distance for the particular voltage. As far as possible the control cabling should also be protected by the same class of conduit, but where this is impracticable it may be enclosed in insulation troughing and the various leads brought out through holes in the troughing at the desired positions.

Interconnections between switches and resistances are best carried out by means of bare copper rods or straps, as these make a better mechanical arrangement and present a more pleasing appearance, since they can be bent at any desired angle. The section of copper should not only be adequate for current carrying capacity but should also be large enough to ensure rigidity. If complete rigidity is not possible without introducing abnormally large cross-sections, then the rods or straps should be secured to structures at one or more intermediate points by means of suitable insulators. As certain of the switches, such as the circuit-breakers, may be called upon to rupture large short-circuit currents in event of a fault developing on the motors or equipment, the arc chutes of such switches should be effectively screened by insulating barriers so that the resulting arcs cannot find a path to ground and cause a failure of the circuit-breaking apparatus.

Underframe-Suspended Equipment

The majority of direct current suburban railway systems using a tension up to 1,500 volts adopt underframe-mounted equipment, and a notable example of a 3,000-volt d.c. line employing the underframe mounting is furnished by the Delaware, Lackawanna & Western Railroad in the U.S.A.

The control equipment for underframe mounting is invariably housed in metal cases. Hitherto heavy cast iron end frames have been generally used for these cases, but the latest practice is to make them wholly of light-gauge sheet steel welded together, and it is found that with this construction a light, strong and rigid case is obtained. The switchgear may be arranged in one or more cases to suit the space available and ensure the best arrangement for accessibility and for conduit and cable lay-out. It is found good practice to suspend the cases and main resistances along the sides of the underframe so as to leave the centre portion free from obstruction when the coach is over a pit, this facilitating the work of inspection and maintenance. Fig. 3 shows a typical underframe-mounted equipment.

Ventilation Problems

Although the boxes in which the switchgear is housed are made dust-tight and waterproof, an exception has to be made in the case of the circuit breakers and switches used to rupture overload currents. These must be provided with ventilators communicating with the exterior of the cases in order that the gases and metallic vapours produced during rupture of the arcs may be quickly and effectively removed. This ventilation usually takes the form of an extension to the arc chute which is arranged to protrude through the door of the case. It is not possible to prevent all dust and dirt from entering these cases but much can be done with regard to the shape and formation of the arc chute extension, which, while allowing adequate ventilation, prevents the ingress of much of the dust and dirt that would otherwise enter. Fig. 4 shows the switchgroup cases on one of the London-Brighton express trains of the Southern Railway.

It is considered good practice to earth switchgroup cases by bolting them solidly to the underframe in order to obtain the maximum protection for the operating staff, but this practice is unfortunately not often carried out except by British manufacturers. When switchgroup cases are insulated from the underframe, the likelihood of a short-circuit, due to an internal flash-over, is undoubtedly diminished. There was perhaps some justification for the insulated case during the early days of the development of underframe-mounted equipment, but there certainly can be none now, at least for voltages up to 1,500, as several large 1,500-volt British-built installations have been in successful operation with earthed cases over lengthy periods.

There is no need to protect the main resistances against accidental contact, since they can be under tension only when the coach is in motion. It is, however, desirable to protect them from mechanical damage due to ballast thrown up by the carriage wheels occasionally resulting in the breakage of a resistance grid. Adequate protection against this risk may be provided by fitting an expanded metal screen around the resistance frames. In the case of 3,000-volt installations it may be considered desirable to mount the circuit-breaking apparatus inside the coach in a special cubicle, while leaving the main part of the switchgear and main resistance beneath the underframe. This arrangement has much to commend it, provided there is no objection to a small cubicle inside the coach, since the insulation and ventilation of the apparatus for this higher voltage can then be more easily and effectively carried out.

The installation of the conduit and cable is no less important for an underframe-mounted than for an inside-mounted equipment, and careful attention should be given to the location of the various cases and main resistances so that a minimum quantity of cable and conduit is

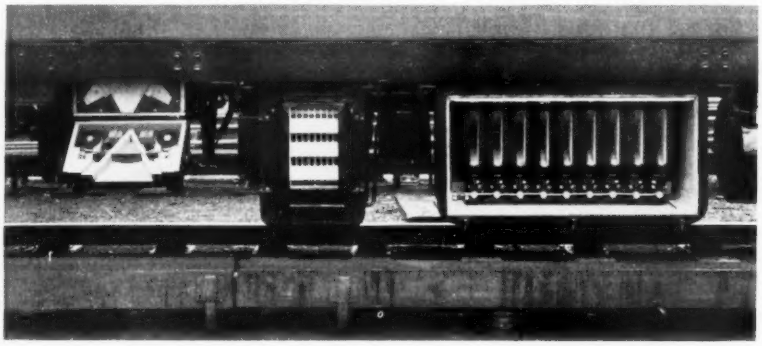


Fig. 4—Switchgroups on Southern Railway train

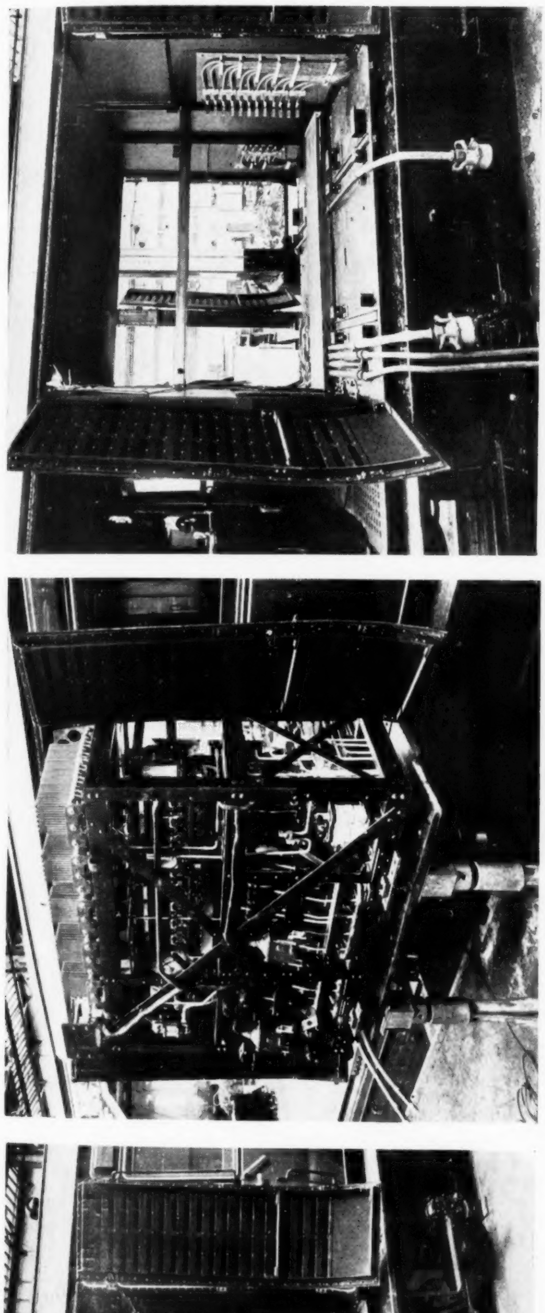


Fig. 5—Three stages in the withdrawal of the control equipment, Euston-Watford trains, L.M.S.R.

necessary and that it presents a neat appearance. Where cases are earthed to the underframe all conduit should enter and be securely fixed to the cases so that electrical continuity is obtained for all earthed metal.

Among the firms which have closely studied the mounting of control equipment with a view to facilitating maintenance work, without encroaching to any appreciable extent upon the revenue-earning space of the vehicle, is the Metropolitan-Vickers Electrical Co. Ltd., and this article is formed on the basis of the experience gained by this company in the design and construction of such units as the Southern Railway main-line and suburban multiple-unit stock, and, among others, the trains of the Buenos Ayres Western, Central Argentine, New South Wales Government, and Netherlands Railways.

Battery Traction in France and Germany

Interesting particulars are given in a recent issue of our contemporary, *La Traction Electrique,* concerning the working of five electric battery railcars over a metre-gauge railway in the south-west of France.

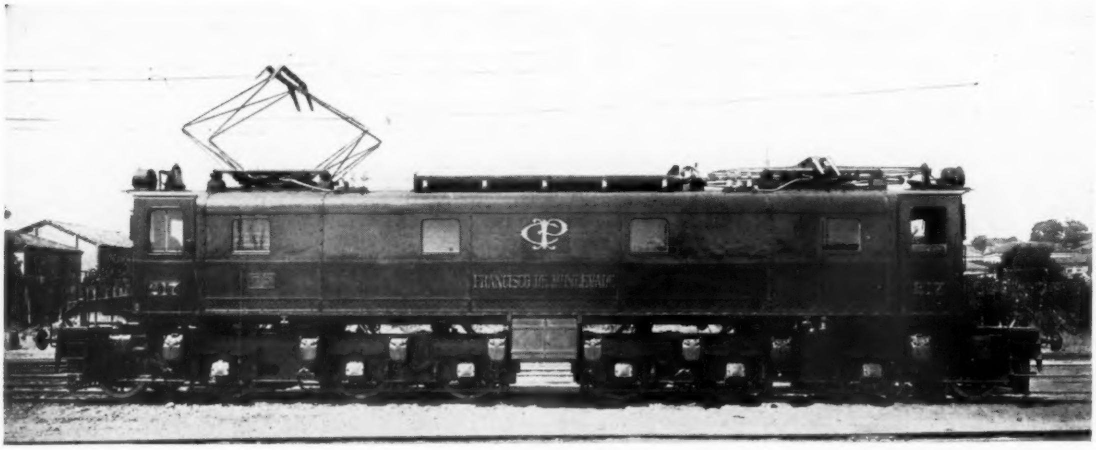
Operating over a 30-mile line out of Toulouse, on which the grades are as steep as 1 in 36 for $2\frac{1}{4}$ miles, these vehicles are of the double-bogie type, with four 50 h.p. 125-volt nose-suspended motors, which, in contradistinction to normal practice, are slung outwards from the axles, instead of towards the bogie centre. Between the bogies, which are of the bolster type, pitched at a distance of 26 ft., are suspended the Tudor Ironclad batteries. These are arranged in five crates with 27 cells in each, the total capacity at the five-hour rate of discharge being 800 amp. hr., and the weight $11\frac{1}{2}$ tons. The control and grouping of the traction motors is carried out by means of electro-magnetic contactors, and the two motors on each bogie are permanently connected in series. The tare weight of the railcar is $33\frac{3}{4}$ tons, and a maximum tractive effort of 10,200 lb. is developed. Further main particulars are: Length over buffers, 46 ft.; bogie wheelbase, 5 ft. 4 in.; wheels, 32·5 in. dia.; max. speed, 37 m.p.h.; seating capacity, 8 first-class and 32 second-class. The car body is built up of aluminium sheets, and contains luggage and postal compartments. Isothermos axleboxes are incorporated, and four sets of air sanding gear are provided. Westinghouse and hand brakes are fitted, in addition to a simple type of automatic regenerative braking, which is effective down to a speed of five or six miles an hour.

Two trailer coaches, with a weight of 20 tons, are hauled over the whole line, and three trailers scaling 34 tons over the level sections. Trials have shown that on stopping trains over generally level lines, it is possible to run for 68 miles without recharging the batteries, and a series of tests carried out between Toulouse and Boulogne (Haut Garonne), a return distance of $60\frac{1}{2}$ miles, but nearly all uphill in one direction, indicated that two trailers could be hauled at a schedule speed of 18 m.p.h. including 25 stops, with a current consumption of 587 amp. hr.

Of the 208 accumulator-driven railcars constructed between 1898 and 1928 by the German State Railway and two of its predecessors, the Prusso-Hessian State and Bavarian Railways, 18 were handed over to Poland and seven to the Alsace-Lorraine Railways after the war. 168 cars still remain the property of the Reichsbahn, and according to the *Bulletin of the International Railway Congress* these vehicles covered 6,525,000 motor-car miles, of which 1,864,000 miles were with a trailer. They are regularly employed over lines totalling 4,660 miles.

PAULISTA RAILWAY ELECTRIFICATION

Greatly reduced operating charges result from conversion of 200-mile broad-gauge line in Brazil

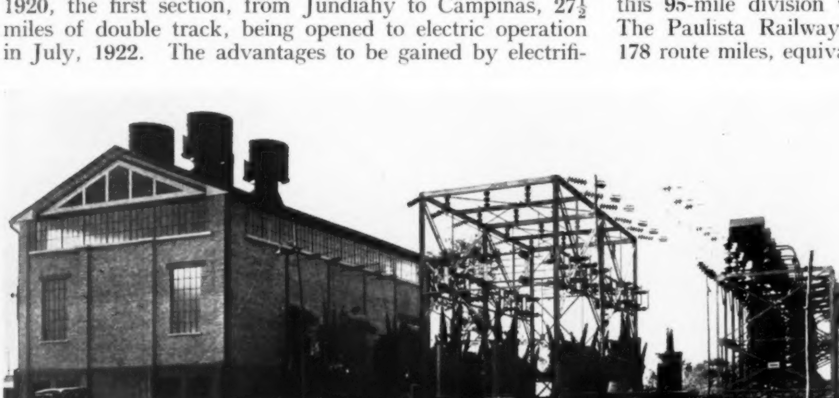


2,340-h.p. Metro-Vick passenger locomotive, Paulista Railway

A DENSE and important traffic in coffee, cereals, hides and meat is in normal times carried over the Paulista Railway, which operates 462 miles of 5 ft. 3 in.-gauge route, 438 miles of metre-gauge, and 38 miles of 600 mm.-gauge in Brazil. At the southern terminus at Jundiahy, a junction with the 5 ft. 3 in.-gauge Sao Paulo Railway gives connection with the important Atlantic seaport of Santos.

The fuel difficulties commonly experienced on Brazilian railway systems pressed with particular force on the Paulista Railway after the war, for certain heavily-graded sections of that company's main line were rapidly reaching the limit of the capacity of steam traction. Electrification on the 3,000-volt d.c. system was decided upon as a remedy, and conversion work commenced in October, 1920, the first section, from Jundiahy to Campinas, 27½ miles of double track, being opened to electric operation in July, 1922. The advantages to be gained by electrification were very clearly demonstrated by the working results of this section, where in twelve months the cost of operation was reduced to 19·3 cents per train mile from 63·09 cents with steam traction. The total cost of working, including maintenance and repairs of rolling stock, permanent way, distribution system, &c., was reduced from 69·92 cents per train mile with steam working to 22·97 cents with electric operation.

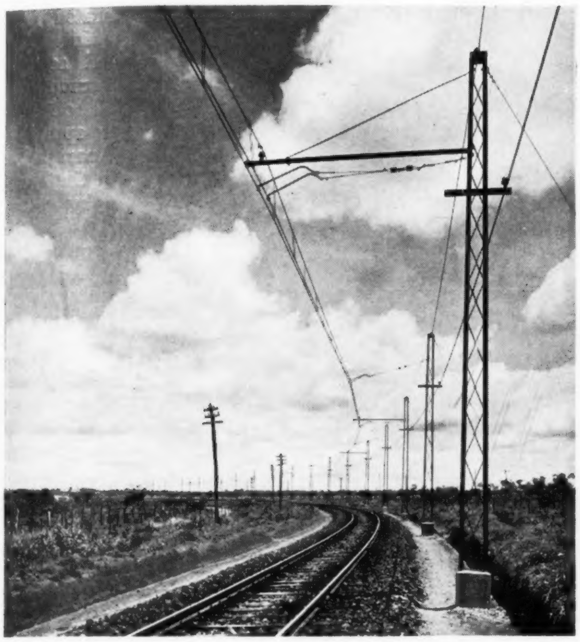
Such results naturally led to an extension of the electrified lines, and the 31 miles of single track from Campinas to Tatu were opened to electric traction in November, 1925, and the remaining 25 miles on to Rio Claro in December, 1926. Despite unfavourable financial conditions, it was decided to prolong the electrified section on through Sao Carlos to Rincao, and the conversion of this 95-mile division was completed in December, 1928. The Paulista Railway thus operated by electric traction 178 route miles, equivalent to a total track mileage of 252, the largest electrified system in South America.



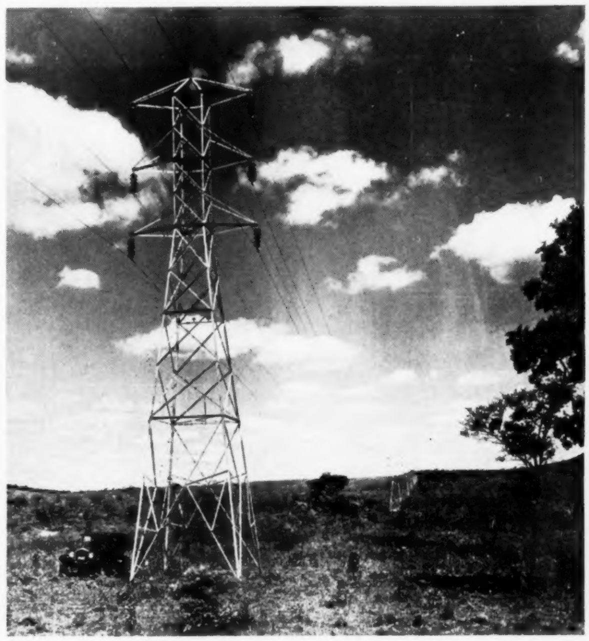
Semi-outdoor substation at Ouro

Current is received in bulk from the Sao Paulo Hydro-electric Company's power station at Sorocaba, and is led at three-phase 60 cycles 88,000 volts to eight converting sub-stations. Three of these sub-stations, Louveira, Reboucas, and Cordeiro, are on the first division from Jundiahy to Rio Claro, and the remaining five, situated at Camaquan, Ityrapina, Sao Carlos, Ouro, and Rincao, are on the second division of the railway, which extends from Rio Claro to Rincao.

The transmission lines of



Overhead construction, Sao Carlos to Rincao



88,000-volt transmission line

both divisions are composed of two lines of copper cables, with an earthing wire of copper attached to the top of the pylons. An unusual feature is that from Sorocaba to Louveira the pylons are of wood, and thereafter of steel, with insulators of the Locke-Hewlette type. The substations on the first division and from Sao Carlos to the terminus of the electrified section at Rincao are equipped with 3,000-volt 1,500-kW. synchronous motor-generator sets, those on the first division being of the indoor type, manually operated, but those between Sao Carlos and Rincao are of the semi-outdoor automatic type. The electrical equipment on these two sections of line was supplied by the General Electric Company, of Schenectady, and on the intervening 45 miles from Rio Claro to Sao Carlos by the Westinghouse Electrical & Manufacturing Co., which installed converting sets of 2,000 kW. capacity.

Over the General Electric sections the catenary for the contact line is of the rigid type supported on brackets. On the Sao Carlos-Rincao division these brackets are supported on Truscon steel poles, but between Jundiahy and Rio Claro three types of construction are used, viz.:—

a . . . . wooden poles with cross span, on the double-track section from Jundiahy to Campinas.

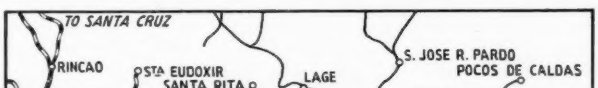
b . . . concrete poles and steel brackets on the single-track section from Campinas to Tatu.

c . . . . Truscon steel poles on the single-track section from Tatu to Rio Claro.

From Rio Claro to Sao Paulo the Westinghouse Company installed an inclined catenary suspended from brackets mounted on Jucho steel poles. This catenary is made up of a composite copper-brass feeder-messenger supporting two hard-drawn copper grooved trolley wires, the actual height of which above the rail varies from 17 ft. to 21 ft. A copper return cable runs along the top of the contact wire poles, and is taped off to the rails at every sixth or seventh pole. Between Jundiahy and Rio Claro the railroads are 4/0 cables, 3 ft. 6 in. long, with pin-driven terminals, but on the second division up to Rincao they are of the 7-in. flame-welded type. Both types of overhead construction and the transmission line are shown in accompanying illustrations.

Seven classes of electric locomotives, totalling 45 machines, are in service, but two types of express passenger units are represented by only one locomotive each, viz., the Metro-Vick 2,340 h.p. 1-Co+Co-1 and the Brown-Boveri 3,180 h.p. 1-Do-1 designs. Leading particulars of all classes are included in the attached table.

A feature of all the locomotives except the double-bogie



Map of Paulista Railway electrified system

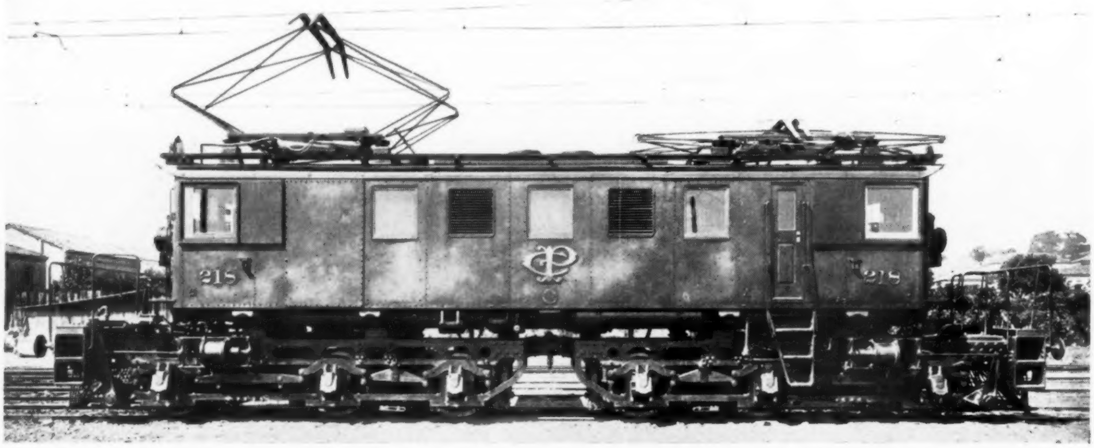
Overhead construction, Rio Claro to Sao Paulo

switchers is that regenerative braking is incorporated, and it has been found that under normal service conditions the current regenerated over the whole electrified section averages **13** per cent. of the train power consumption. In addition, all the locomotives are braked on the Westinghouse system, but have apparatus for applying the automatic vacuum brakes on the train. Apart from the Met-Vick and Brown-Boveri productions, all the locomotives have been designed and manufactured by either the General Electric Company (U.S.A.) or the Westinghouse Company, and embody bar frames, equalised spring rigging, cowcatchers, and other North American features, although normal side buffers and screw couplings are used. The maximum speed of the trains is at present limited to **50** m.p.h., but the maximum safe speed of the passenger locomotives varies from **56** to **65** m.p.h.

Three of the passenger locomotives built by the Westinghouse Company have double-armature motors with Westinghouse quill drive, and are noteworthy, along with the Metro-Vick units, in that the motors are wound for **1,500** volts per commutator, so that each twin-motor has **3,000** volts across its terminals. The only other locomotive with individual axle drive running on the Paulista Railway is that supplied by Brown-Boveri in **1929**. This locomotive has four double-armature motors, whose torque is transmitted to the wheels through the well-known Brown-Boveri drive. An axle-load of no less than **24** tons is borne by this machine, and slightly exceeds that of the Westinghouse passenger and G.E.C. freight locomotives, whose axles are loaded to **23** and **22·3** tons.

LEADING PARTICULARS OF ELECTRIC LOCOMOTIVES, PAULISTA RAILWAY

Wheel arrangement	Bo – Bo	Bo + Bo	Co + Co	2 – Bo + Bo – 2	1 – Co + Co – 1	1 – Bo + Bo – 1	1 – Do – 1
Service	Shunting	Freight	Freight	Passenger	Expr. Passr.	Expr. Passr.	Expr. Passr.
Running Nos.	300–308	204–211	214–215 218–225	200–203	217	212–213 216	320
Builder	G.E.C.	G.E.C.	Westinghouse	G.E.C.	Met.-Vick.	Westinghouse	Brown-Boveri
Drive or motors	N.S.	N.S.	N.S.	N.S.	N.S.	Quill	Individual axle
Length over buffers, ft.	41–6	39–2	50–2	55–0	59–0	52–11	53–2
Total wheelbase, ft.	30–4	26–8	37–0	46–0	49–8	41–2	38–9
Rigid wheelbase, ft. in.	8–0	8–8	14–0	7–9	14–0	8–4	6–11
Driving wheel diam., in.	40·0	42·0	40·0	42·0	42·0	63·0	63·0
Total h.p. (1-hr.)	656	1,828	1,680	1,828	2,340	2,240	3,180
Tractive effort (1-hr.), lb.	21,560	32,200	32,400	16,370	21,000	19,800	28,100
Corresp. speed (1-hr.), m.p.h.							
Adhesion weight, in w.o., tons	55·0	89·5	104·5	71·5	77·5	91·0	95·0
Mech. portion weight ,,	30·7	51·5	65·0	70·5	65·0	74·0	?
Elect. portion weight ,,	22·3	34·0	35·8	34·5	33·6	48·5	?
Total weight in w.o., ,,	55·0	89·5	104·5	107·0	100·0	126·0	121·0



American-built electric freight locomotive, Paulista Railway

ELECTRIC HEATING OF RAILWAY CARRIAGES

New system for use on rolling stock for international trains

THE heating of main-line coaches used in long-distance international traffic, or circulating throughout five or six countries, as is the practice in Europe, presents certain difficulties, for the vehicles must not only be fitted with steam heaters, but also with electric apparatus suitable for operation over various electrified systems which have not the same type of current or voltage.

On d.c. lines the heating apparatus usually operates at the contact line pressure, and as there are a number of d.c. systems working at 1,500 volts, apparatus working at this tension is commonly found on the Continent. Within recent years a number of d.c. electrifications have been carried out or planned, *e.g.*, in Italy and Poland, at a pressure of 3,000 volts, and heating apparatus to suit this current will be one of the requirements of the future. Most of the single-phase railways employ that type of current at 1,000 volts for the heating equipment of the rolling stock, and the systems at present used for connecting the 1,000 a.c. and 1,500-volt d.c. heating circuits are none too simple, and the re-connection is carried out by hand. With the possibility of yet another voltage, it is obvious that there is room for a scheme which will not only be capable of dealing with the three different heating systems, but which will also possess the feature of automatic re-connection to the correct voltage.

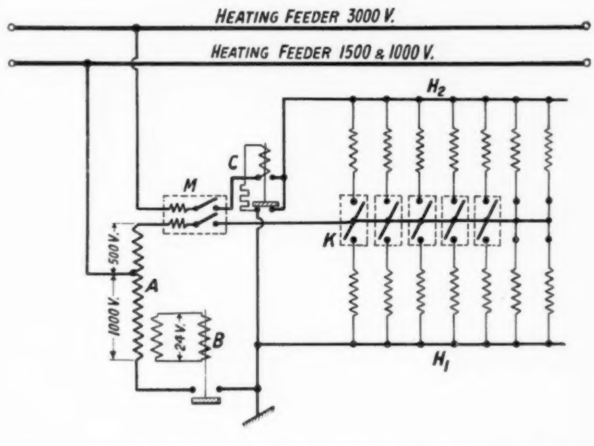
With these ends in view, Mr. Ivan Ofverholm, the Chief Electrical Engineer of the Swedish State Railways, has evolved a plan in which each coach is fitted with two through-running heating feeders, one for 3,000 volts and the other for 1,000-1,500 volts, as may be seen from the accompanying wiring diagram. The low-voltage line will be arranged down the underframe, as at present, but the high-tension feeder will be laid along the roof. The heaters are dimensioned to suit a tension of 1,500 volts, but half of the heaters, H_2 in the diagram, are insulated in such a way that when connected in series with the other half, H_1, they can withstand a voltage to earth of 3,000.

Automatic Adjustment

To permit of an automatic change-over from 1,000 to 1,500 volts, there is incorporated an auto-transformer, A, with an auxiliary winding which is connected to the solenoid of an automatic switch, B. If the feeder is on 1,000 volts a.c., the auto-transformer becomes magnetised by a current led through the 500-volt winding, which is permanently connected in series to a few of the heaters. The solenoid of switch B then receives current and the transformer earth circuit is closed. By means of the step-up transformation the two groups of heaters are supplied with a voltage of 1,500 and are connected in parallel to earth. If the feeder voltage is below 1,000, the voltage in the heaters is proportionately less than 1,500, and the heating effect correspondingly lower.

Where the feeder is alive at 1,500 volts d.c., the transformer does not function as such, and as the solenoid of switch B does not receive current, the earth connection is not made, and the heaters receive current direct at 1,500 volts through the 500-volt winding of the transformer. With 3,000 volts on the feeder, the change-over switch, C, automatically connects the heaters in series at 3,000 volts by means of a solenoid connected direct, or through a resistance to the high-tension supply. The common connection, K, of the two heater groups, is permanently connected, through an over-current breaker, to one end of the transformer winding, and thus to the low-tension heating feeder. As the connection between 1,000 and 1,500 volts can be effected by a simple relay and low-tension operating coil, it can be made fully automatic under all conditions, although hand operation can be fitted in addition.

There is a possibility of the solenoid of the switch B, if connected up as shown in the diagram, being momentarily magnetised, and closing the contact when the feeder is taking d.c., thus earthing the feeder, and to prevent such an occurrence the switch can be given time-lag, or an auxiliary relay may be incorporated.



Wiring diagram of Ofverholm train-lighting system for international carriages

Since the insulation of the feeders hitherto used for 1,000 and 1,500 volts does not permit a tension of 3,000 volts being applied without precautions being taken, and since the various connections are not designed for so high a voltage, such an arrangement with two feeders can probably be considered as the most suitable solution. The new 3,000-volt feeder would be provided with considerably heavier insulation than that now internationally used for 1,500 volts. Should it be a question of employing a common feeder, due to which the already installed feeder in coaches in service must be reinforced, then the system can easily be adapted for the purpose. Resort can be had to relatively simple change-over switches or relay combinations which can be arranged according to different methods and wiring principles already well known. We are indebted for much of the foregoing information to the Asea Journal, published by the Swedish General Electric Company.

BOLOGNA-FLORENCE DIRETTISSIMA.—The new direct line of the Italian State Railways between Florence and Bologna, which reduces the distance between Rome and Milan by 21½ miles, is to be opened during the coming spring. The line includes a tunnel 11½ miles long through the Apennines, and is to be operated by electric locomotives working on the 3,000-volt d.c. system.

THE UNDERGROUND

Complete electrical equipment by British manufacturers

Control room at Wood Green substation

CARRYING approximately 400,000,000 passengers a year in 3,143 cars covering 115,000,000 car-miles over 222 miles of route, the London Underground, now but one of the several branches of the London Passenger Transport Board, ranks as the leading urban railway system of the world. The reputation which the Underground bears for intensive and efficient service is largely due to the up-to-date electric generating, transmission, and traction equipment which has been a characteristic of the various companies since the inception of the first real tube railway, the City & South London, in 1890.

In an attractive and well-presented volume of 83 pages, entitled "Electrical Equipment for London's Underground Railways," which has just been issued by the British Electrical & Allied Manufacturers' Association (Inc.) from their offices at 36 and 38, Kingsway, London, W.C.2, the development and capacity of the plant which, by the generation and conversion of 1,540,000 kWh. per day, runs 394 trains in 24 hours, with a maximum density of 40 trains an hour, are illustrated and described.

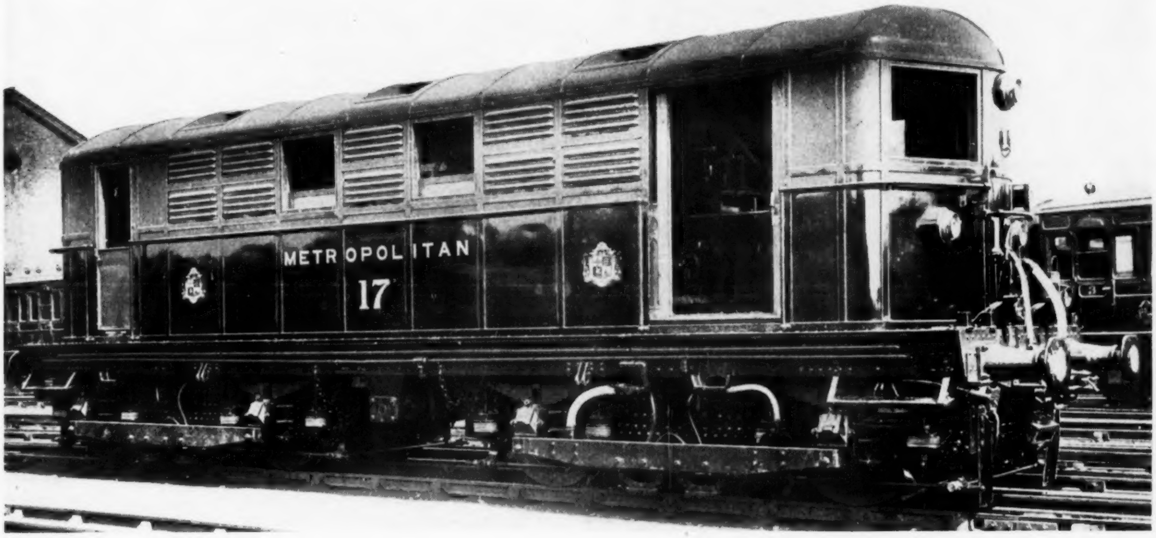
Since the formation of the London Passenger Transport Board, the Neasden power station of the former Metropolitan Railway has been brought into the Underground group, and in conjunction with the Lots Road station at Chelsea, which has served the growing needs of the tube railways proper since 1905, now supplies the bulk of the power required by the L.P.T.B., including the ex-London United Tramways. The combined peak capacity of these stations is in neighbourhood of 300,000 kW., of which two-thirds is produced by the generators at Lots Road.

The complete turbo-generator plant at Neasden, from the original machines of 1904 to the two 25,000 kW. sets recently installed, has been manufactured by the Metropolitan-Vickers Electrical Co. Ltd., or its predecessors. The main 11,000-volt three-phase switch gear, which was renewed in 1921-22, was supplied by the General Electric Co. Ltd. of Witton, and is arranged in three floors. Lots Road station contains generating equipment by a number of makers. but the main switchgear, which controls the turbo-generators and the distribution of power to 66 outgoing feeder circuits, was supplied by the British Thomson-Houston Co. Ltd.

In view of the heavy traffic and the necessity of keeping the voltage drop along the track as low as possible, the substations are numerous. There is a total of 62, of which 53 are owned by the L.P.T.B. and supplied from Lots Road or Neasden. They vary in capacity from 1,800 to 10,000 kW., and for their equipment member firms of the Beama have supplied rotary converters aggregating over 200,000 kW., together with the ancillary transformers and switchgear.

Success of Mercury Rectifiers

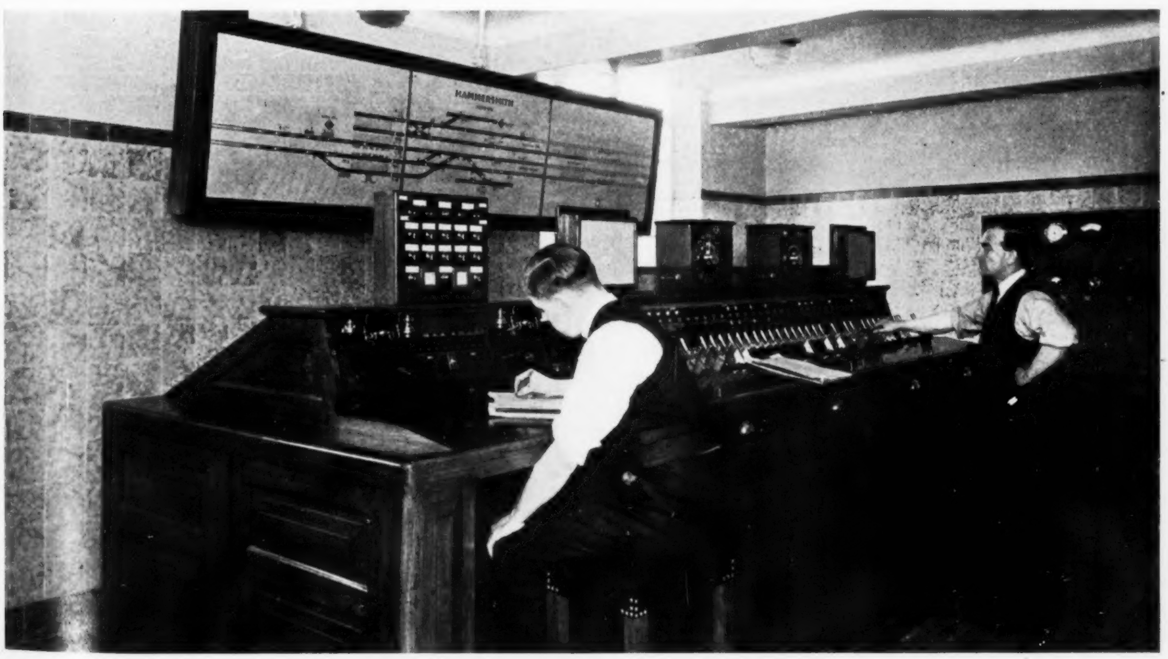
As a result of the extremely satisfactory performance of the steel tank mercury rectifiers installed at Hendon in 1930, the railway authorities early in 1931 awarded the B.T.H. Company the largest contract for rectifier plant ever placed in this country. The order covered the equipment for the whole of the substations required for the Cockfosters extension, as well as for a number of other substations on the system, including those on the western



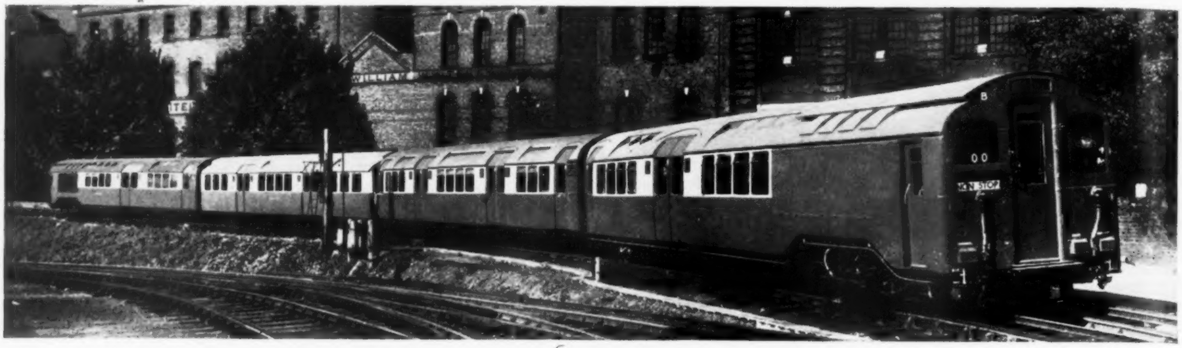
1,200 h.p. electric locomotive, Metropolitan Railway section, L.P.T.B.

extensions of the Piccadilly line. The G.E.C. were the contractors for the thirteen rectifiers installed in the sub-stations at Chiswick Park, North Ealing, Alperton, Sudbury Hill, and Northfields. For continuously re-cooling the circulating water of these rectifiers, Heenan & Froude Limited has supplied a number of air-blast water coolers.

When the City & South London Railway was promoted it was proposed to use cable haulage for the trains, but on the suggestion of Mather & Platt Ltd. electric locomotives were adopted, and the first locomotives were built by that firm, and by Siemens Bros., and Crompton & Co. Multiple-unit stock was introduced on the Central London line in 1903, with vehicles built by B.T.H. Only multiple-unit trains have been employed on the tube lines since, but the Metropolitan section still operates twenty electric locomotives in addition to its multiple-unit stock, all of which has been electrically equipped by Met-Vick and the G.E.C. The locomotives are 1,200 h.p. rebuilds of the older 800 h.p. units, and haul trains with an average weight of 160 tons at speeds up to 60 m.p.h. They weigh $61\frac{1}{2}$ tons, and are employed on the suburban services from



Interior of new signal-box at Hammersmith



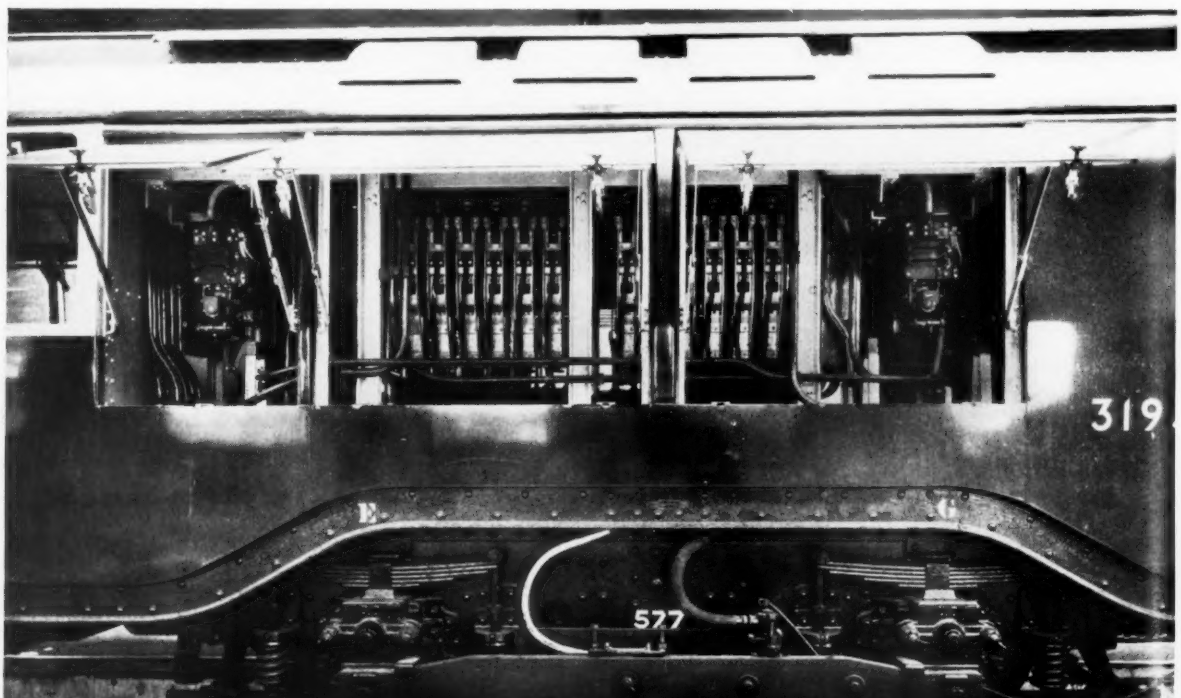
Four-car train, Underground Railways

Aldgate, stopping at all stations to Baker Street, and then on certain services running non-stop to Harrow. Control for multiple-unit working is provided.

As an indication of the magnitude of the Underground, it may be mentioned that during the last eight years no fewer than 1,668 traction motors of 240 h.p. have been supplied to the old London Electric Railways and Metropolitan district Railways by the G.E.C. alone. The normal Underground stock is arranged for operation either as seven, six, four, or three-car units, the seven, six, and three-car trains of the latest type taring respectively 168, 136, and 68 tons, and including three, two, or one motor coaches. The seven car sets—made up of three motor coaches and four trailers—have a horse-power of 1,440, permitting a schedule speed of 25 m.p.h. including stops.

The illustration below, showing the control gear in one of the new motor coaches, forms an interesting addition to the article on the layout of control gear in multiple-unit trains, which we publish on pages 72–75 of this issue, and illustrates the manner in which the control equipment can be mounted in a separate compartment above the bogies, even when the loading gauge is stunted.

Comprehensive details of the Underground equipment were given in the special supplement presented with The Railway Gazette for November 18, 1932, but the above information, taken from Beama's latest volume, are sufficient to give an indication of the manner in which British manufacturers have, over a period of many years, met the stringent requirements of the various railways which, until the formation of the London Passenger Transport Board in July last, made up the tube system of the Metropolis.



Contactors and circuit-breakers mounted in special compartment above the bogie, Underground motor-coach

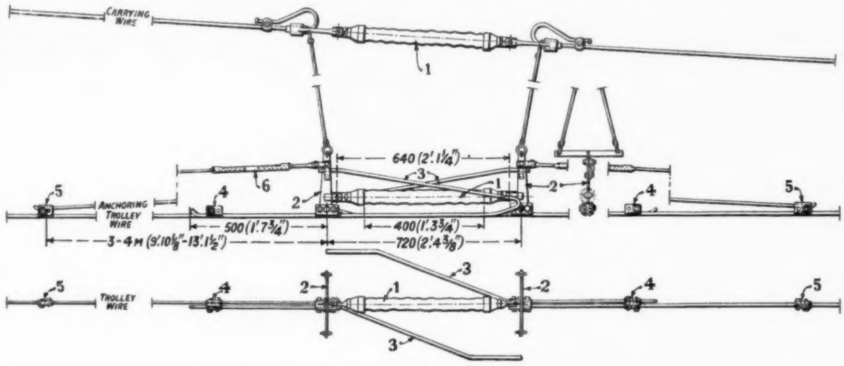
REDUCING THE WEIGHT OF CONTACT LINES

By Ad. M. HUG, M.I.Mech.E.

WEIGHT saving in overhead construction is an important matter for railways with a relatively low voltage (1,500-3,000 volts d.c.), for the currents are high, and necessitate large wire sections. A heavy head line, or catenary, involves some risk in service owing to the greater suspended weight, and to the fact that all of the supporting devices have to be stronger. Weight saving results on one hand from the use of a lighter material, and on the other from an indirect saving, in consequence of a better or more rational disposition. As an application of the latter may be mentioned the anchoring of the wires from both sides of a mast, which is better than anchoring on one side only. A wire anchored from one side needs a much stronger supporting device and a stronger construction of the mast. Light supporting clips for catenaries have been applied for many years, and on one system breakages have been greatly reduced by replacing the brass clips with units of aluminium.

For railway catenaries, especially on main lines where trains are operating at speeds up to 60-80 m.p.h., it is important to have light switching apparatus, and for this type of work an interesting device has recently been introduced on several electric railways in Switzerland, Morocco, and other countries. This patented reinforced insulator, known as the " Z-S " type, has a much lower weight than those usually applied for sectioners. One of these insulators has a weight of only 5 lb. as compared with the usual porcelain insulator weighing 20 to 40 lb. The accompanying drawing shows a line sectioner with insulators of this type as used by the Swiss Federal and other railways.

This " Z-S " insulator, patented by W. Schabelitz, is claimed to possess a light weight, great reliability in operation, cheap erection, and security against breakage, and it is easy to keep clean. It is a high-tension insulator for horizontal or vertical attachment to the live conductors, comprising a tension rod which extends between the conductor fitting at both ends. This rod is made of a vegetable insulating material of a high di-electric strength enclosed in a protective cylinder composed of ceramic matter and providing a high electrical surface resistance; the cylindrical hollow space between the rod and the cylinder is filled with an insulating material. The outside diameter of the ceramic cylinder is about 2 in., and the ends of the rod are grooved and fitted into tightly-closing sleeve-shaped metal members of the conductor gear. To avoid the influence of air and humidity, the protective cylinder is fitted with lead-shaped members connected by a special process to a metallic ring. The ends are covered by shapes of tinned copper for protection against melting whenever a flash-over takes place in the system.



Line sections erected with " Z-S " insulators

The " Z-S " insulator has the advantage, as compared with other ceramic insulators, that the mechanical forces are taken up only by very strong pieces. Official tests made with the rod show a specific load of nearly 11,000 lb. per sq. in. The ceramic cylinder protects the rod insulator so that the core never can be destroyed in such a way that the wires could fall down. The normal rod insulator has an insulating distance of about 15 in., and a distancing length of 27 in. The flash-over voltage in dry conditions is about 145 kV., and the insulator weighing only 5·3 lb. is tested normally with 3 tons tension over 2 min. The breaking resistance is about 5 tons, and the test tension is made in dry conditions with 130 kV. over 15 min. The second illustration shows several applications at Aesch station, near Basle, on the Swiss Federal Railways. In this illustration the " Z-S " patent is shown as a supporting isolator, as a horizontal insulator or sectioner, as a distancing isolator from the mast, and as equipped for a line sectioner as shown above.

" Z-S " insulators at Aesch, near Basle

NOTES AND NEWS

Capetown Suburban Line.—It is understood that the South African Railways intend to proceed almost at once with the electrification of the ten-mile line from Maitland to the Diep River, known as the Cape Flats section. The system used will be 1,500 volts d.c.

Spanish Electric Locomotives.—Four metre-gauge 1,000 h.p. double-bogie electric locomotives have recently been delivered for service on the Bilbao-San Sebastian section of the Vascovgados Railway. The electrical equipment was supplied by the Swedish General Electric Company (Asea), and the mechanical portion constructed in Bilbao.

Indian Electrification Success.—Sir Ernest A. S. Bell, C.I.E., who presided at the recent annual meeting of the South Indian Railway, said, in the course of his speech, that it was pleasing to record that the results from the electrification of the Madras suburban area continued to give satisfaction. Comparative costs of steam and electric operation had been carefully worked out, which showed a satisfactory return on the capital outlay, and so far as it was possible to foresee, the results would justify expectations.

Further African Conversion.—The 1,500-volt d.c. electrified division of the Moroccan Railways between Rabat, Casablanca, and Rourigha, which has been in operation since 1927, has recently been extended from Ben Guerir to Marrakesh, 40 miles, and since January 1, electrically-hauled passenger trains have been running through from Casablanca to Marrakesh. Reuter reports that the time taken between these two towns is only four hours, although the distance is 215 miles, and the electric locomotives are of the double-bogie type.

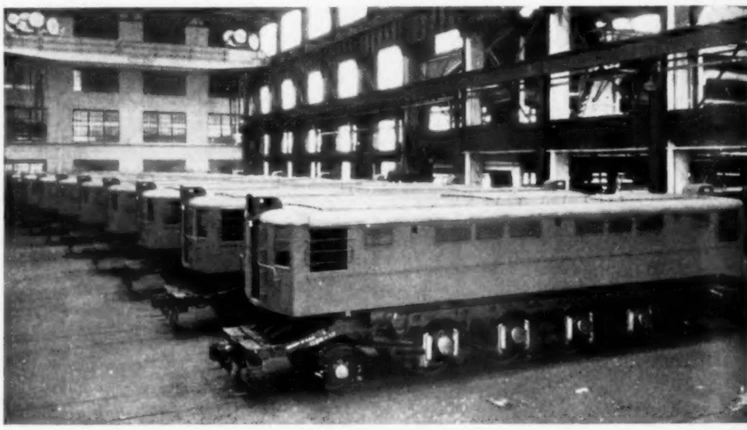
Electric Extension in Natal.—It is reported that the South African authorities have decided to electrify the line from Daimana junction, just outside of Ladysmith, to Harrismith, in the Orange Free State. This 60-mile section forms part of the mail-train route from Natal to Kimberley and Capetown, and in the first 37 miles out of Ladysmith climbs 2,300 ft. It is also believed that the administration of the South African Railways is contemplating the extension of electric working from Cato Ridge to Durban, but a decision is being deferred until the completion of the report of Sir Guy Granet and Mr. Hans Meyer, who are now investigating the railway situation in the Union.

Notable P.O. Performance.—On the occasion of the recent visit of Gen. Vaugoin, Chairman of the Austrian Federal Railways, the Sud Express, which is normally of light formation, maintained the scheduled time between Paris and Les Aubrais despite a ten-minute stop, thanks to a special authorisation raising the speed limit from 120 to 150 km.p.h. (74·5 to 93·7 m.p.h.). Between Juvisy and Les Aubrais, the Etampes grade of 6¼ miles at 1 in 125-500 was climbed in 5 min., the speed at Guillerval station at the summit being 82½ m.p.h., and for a distance of 4¼ miles between Monnerville and Boisseaux, and for 1½ miles between Chateau-Gillard and Artenay, a speed of 93·5 m.p.h. was maintained.

Another Electric Railway in Spain.—The Spanish Ministry of Public Works has approved the proposals for the electrification of the broad-gauge Norte line between Vittoria and Mecolalde, a distance of 38 miles. It is reported that the cost of conversion will be in the neighbourhood of 10,000,000 French fr.

Italian Power Scheme.—A new powerful boracic steam crater having opened about six miles from Larderello in Tuscany, the engineers of the Italian State Railways are to prepare a plan for utilising its power for the generation of current for electric traction. This scheme will be based upon the experience gained with other similar craters, and it is estimated that 20,000 kW. will form the capacity of the new source of power.

Jugoslavian Electrification Proposals.—The Jugoslav Council of Towns is appointing a committee to prepare a scheme for the electrification of the country, including the national railway system, for submission to the Government, which is understood to view these projects with favour. It is reported that two French firms have already put in tenders for the erection of the power stations and the electrification of certain sections of railway.



Erection of 2,500-h.p. electric freight locomotives for the Pennsylvania Railroad at the Lima Locomotive Works

Electric Construction in Scandinavia.—Two new lines, which on their completion will be worked electrically, are now being constructed by the Norwegian State Railways. The first is a 16-mile branch from Voss on the Oslo-Bergen line to Eide on the Hardanger Fjord, and the second a 15-mile branch from Myrdal, on the same main line, down to Fretheim on the Sogne Fjord. The difference in level between the two terminal points on the latter line is 2,800 ft.

Austrian Mountain Line Converted.—The northern bank of the well-known Tauern line, which runs south from Schwarzach St. Veit on the Salzburg-Innsbruck main line, has recently been opened to electric working on the standard 15,000-volt single-phase system of the Austrian Federal Railways. The average gradient is 1 in 40 for 13 miles, and the line includes the 5¼-mile Tauern tunnel. The southern section, from the summit at Mallnitz down to the Millstattersee, is to be electrified during 1934.

ish
for
een
is
gh-

cic
ello
ays
era-
be
ilar
the

go-
are
ing
ern-
vith

ady
and

new
ally,
Rail-
the
and
ame
The
on

hern
outh
ruck
g on
rian
for
nnel.
own